1996

Avian Communities in Australia and Redlands

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Assessment of avian communities in the various habitats along a proposed corridor on the Atherton Tableland, North Queensland, Australia

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December 8, 1995
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Abstract

This study from November through early December 1995 examines bird populations present along a partially vegetated riparian rainforest restoration corridor on the Atherton Tableland in Northern Queensland, Australia. Habitats ranged from mature rainforest to grassland. Species composition and diversity among the various habitats along the corridor was assessed using point censusing and mist netting. One hundred twenty one birds were mist netted and banded for use by future researchers. One bird was recaptured and found to have moved from a fragment to regrowth. Point censusing determined that 69 bird species, specifically 51 rainforest species, were using the corridor site. Mobility groupings ranging from mobile to non-mobile were determined. All 15 Wet Tropic endemic species and subspecies that are present at the site were censused in the mature rainforest and regrowth areas. Eight foraging guilds were determined to be present along the corridor site, yet the presence of several guilds was lacking in the more open sites. The regrowth was determined to have the same species composition as the mature rainforest. Although at this time the corridor site is not being used by all species censused, growth of the January 1995 plantings and future plantings along other portions of the site show promise in conserving the bird populations present and preventing the extirpation of many endemic species and subspecies.

Introduction

The once continuous rainforest of the Atherton Tablelands in North Queensland is now fragmented due to logging and agricultural clearing (Tracey, 1986). Fragmentation is detrimental to faunal diversity (Lovejoy et al., 1986) and thus the long term viability of avian populations is questionable. Fragmentation reduces the populations of many birds, thus making them vulnerable to environmental changes as well as stochastic, demographic and genetic effects (Laurance, 1991). Non-mobile rainforest birds, birds that cannot move through open non-forested areas, can only mate with those birds in the fragment and therefore are likely to suffer from genetic isolation and the possibility of extirpation.

There are 15 bird species or subspecies that are endemic to the Tableland (Blakers *et al.*, 1984). Protecting the long term needs for foraging and breeding habitats of these species is of critical importance in order to prevent extirpation. One proposed solution for fragmentation is to plant corridors between existing fragments for the purpose of wildlife conservation (Lindenmeyer, 1994). Corridors of planted native vegetation potentially allow for physical movement of birds and genetic interchange between bird populations. Noss (1987) states that corridors may increase immigration to a fragment, increase foraging area and increase the mix of habitats and successional stages available to the animals using the corridor.

The main problem with corridors is that their effectiveness has not been fully ascertained. Simberloff and Cox (1987) point out that it is unknown whether deep forest species will use the corridor. Since most deep forest species are non-mobile, this implies that only mobile species may benefit from the corridor. Mobile species are species that can survive in rainforest habitat, including regrowth, and that can move over open areas. Laurance (1991) points out that vulnerable animals rarely use secondary vegetation. This implies that specialists may have problems using corridors.

Donaghy's corridor, partially planted in January 1995, runs along Toohey's creek on the Atherton Tableland and will eventually connect the fragmented rainforest of Lake Barrine National Park with the continuous rainforest of Gadgarra State Forest. This study examined the existing bird communities in the various habitats along Donaghy's corridor to help in the long term understanding of the possible uses of corridors. Although the corridor is not fully planted, a preliminary study of the bird communities present will allow us to determine the use of the corridor by comparing present data on species composition and diversity with future studies. Movement of birds along corridors can be determined by comparing future mist netting data with current mist netting data.

Methods

Site Description

The site of this study is continously changing due to the

the planting of new trees and succession. Therefore the site description is accurate for the date of the study but it may have changed since that date and the current date.

The site for Donaghy's Corridor runs along Toohey's creek between Lake Barrine National Park and Gadgarra State Forest on the Atherton Tableland (See Figure 1). The partial corridor is surrounded by private land used for cattle grazing. Future plantings by Queensland Department of Environment and Heritage will take place to create a corridor approximately 80 m in width (Grant, pers. comm.).

Lake Barrine National Park consists of approximately 500 ha. of complex mesophyll vine forest. It is located at 17° 12'S, 145° 36'E on basaltic soil (Tracey, 1986). Lake Barrine National Park has been isolated for about 65 years and has been a scenic reserve since 1888 (Burco, 1995). Lake Barrine National Park is bordered on the eastern side by early successional *Lantana* regrowth.

Gadgarra State Forest is approximately 2000 ha. of mature complex mesophyll vine forest and mature complex notophyll vine forest located at 17° 16'S and 145° 41'E (Tracey, 1986). It is continuous with 900,000 ha of rainforest, including Bellenden Ker National Park. Gadgarra has been selectively logged during this century, but became a part of World Heritage area in December 1988 so logging no longer takes place (Burco, 1995). Gadgarra State Forest is bordered on the western side by 30 year old *Acacia* sp. regrowth.

Half way between Lake Barrine National Park and Gadgarra State Forest along Toohey's creek is a fragment that consists of a mature rainforest canopy but lacks a dense understory. In January 1995 approximately 4000 trees were planted between the fragment and the *Acacia* regrowth that bordered Gadgarra State Forest. Between the fragment and Lake Barrine is a clump of rainforest trees bordering a dam in the creek.

We used two primary methods to sample for bird composition and diversity: mist netting and audio/visual point censusing.

Mist netting

We sampled four sites along the corridor for bird populations using mist netting (Figure 2). Eight nets were set up in the mature forest of Lake Barrine, the *Acacia* forest bordering Gadgarra State Forest and in the mature rainforest of Gadgarra State Forest. Four nets were set up in a rainforest fragment along Toohey's creek. Only 4 nets were set up at this site due to the small size of the fragment. Each site was sampled for 4 days total, without sampling at the same site for more than one consecutive day. Each net was open for approximately 4 hours per day, between 5:45 AM and 9:45 AM. Nets were regularly checked for birds every 30 to 40 minutes. Captured birds were banded, measured according to standard Australian banding procedures, and released from the point of capture.

Mist netting data serves to supplement point censusing data by netting birds that are in residence, but were not heard or seen. Banding birds provides a means of determining movement of birds along the corridor when previously banded birds are recaptured. All recaptured birds were looked up in previous banding records, using the band numbers to determine the original capture and banding points. The data from the original mist netting site, used from late 1994 to early 1995 by Amy Jansen, was compared to the data from our mist netting site to determine if and how the birds had moved.

Point Censusing

We sampled 9 point census sites along Toohey's creek (See Figure 2 for site numbers). Two sites each were censused in Lake Barrine National Park (1,2) and Gadgarra State Forest (8,9). One site each was censused in the *Lantana* (3) bordering Lake Barrine National Park, among a few existing rainforest trees near the dam (4), in the larger rainforest fragment (5), in the January 1995 corridor planting (6), and in the *Acacia* regrowth (7). We chose these sites to determine bird species composition and diversity along the various habitats of the corridor. Each site was audio/visually censused on 12 days for 20 minutes each day by 2 researchers. All censusing was done between 6 AM and 9 AM. The order in which censusing occurred varied each day to prevent bias due to time of the day. Observers noted weather conditions including wind (calm, breezy, strong), rain (none, drizzle, steady rain, downpour), and cloud cover (clear, partly cloudy, cloudy) because weather conditions affect the frequencies of calls. A species was counted twice in a census if two calls were heard simultaneously or if male and female distinctions could be made. This abundance data was not used in analysis due to lack of conformity and assurance in data collection. Birds that flew over the censusing site were recorded and noted as flybys. Researchers rotated through all areas to reduce bias. Point censusing was done as opposed to walking transects to minimize disturbance of the censused areas. A site was not censused when the site was being mist netted.

Data Analysis:

We classified all rainforest species censused into foraging guilds (Appendix 3; Blakers *et al.*, 1984; Grant, pers. comm.) to allow for statistical analysis of species composition between sites. Two guilds, that had only one species present at the corridor site, were excluded. We used Kruskal-Wallis and Rank Sum Tests to compare species composition and diversity between all point census sites.

All bird species were placed into mobility categories (Appendix 4) using our point census and mist netting data along with Burco's data from Spring 1995. Birds that were censused only once were excluded from analysis.

Results

Mist netting Data

There were 121 birds caught in mist nets representing 25 different species over 448 net hours (See Table 1). There were 58 birds mist netted in the *Acacia*. This was the greatest number of birds captured and had a capture to net hour ratio of 0.45. In comparison, there were only 5 birds mist netted in the fragment. The capture to net hour ratio was only 0.08. Two Emerald Doves were mist netted in the fragment but were not counted in the audio/visually census at any site. There were three species mist netted in the *Acacia* that were not observed in the audio/visual census at that site. They include the Mistletoebird, Eastern Spinebill and Pied Monarch. There were 32 and 26 birds mist netted at Lake Barrine and Gadgarra, respectively. The capture to net hour ratios were similar between these two sites, 0.25 for Lake Barrine and 0.20 for Gadgarra. Of the birds recaptured, only 1 had moved through the corridor site. A Little Shrike-thrush moved from the fragment to the *Acacia*.

Point Census Data

We censused a total of 68 species, including 51 rainforest species (Blakers *et al.*, 1984). An additional 4 species were recorded only as flybys. Gadgarra site 1 had the most rainforest species present, 40, while the planting only had 5 rainforest species present. A foraging guild describes the main types of food that a particular bird species eats. Part of the classification can also apply to where the birds forage. For example, Leaf Litter Insectivores eat insects that they pick from leaf litter on the ground. The numbers of species found in each foraging guild are shown in Table 2.

There were 8 foraging guilds found to be using the corridor site. Some of these guilds were not represented at all of the point census sites. There were no Leaf Litter Insectivores (LLI) found at the dam, fragment or planting sites. The dam was also devoid of all Ground Pouncers (GP) and Trunk Gleaning Insectivores (TGI). The Planting lacked Ground Pouncers, Frugivores (F), Trunk Gleaning Insectivores, and Frugivore/Granivores (FGr).

There are 15 Wet Tropic endemic species or subspecies (WTESS) using the corridor site. Of these WTESS, the Macleay's Honeyeater was the only endemic species found at the dam. The Bridled Honeyeater was the most limited species observed, only being found at Gadgarra State Forest.

A Kruskall-Wallis Test was used to compare the mean number of species per guilds within all 9 point census sites. There was a significant difference between sites ($p=0.0001$, $df=71$, $n=72$.) A Rank Sum Test was used to determine the differences between the mean number of species per guild when comparing only 2 sites (Table 3). There was not a significant difference between the species represented per guild in Lake Barrine 1 (LB1) and Lake Barrine 2 (LB2), Gadgarra 1 (G1) and Gadgarra 2 (G2), or average

Lake Barrine (LB) and average Gadgarra (G). Therefore LB and G were combined into a general rainforest sample to do further tests.

Significant differences were found between the rainforest sample and all open sites (Table 3). Open sites include the *Lantana*, dam, and planting sites. The planting was found to be significantly different from the *Lantana*, dam and *Acacia* regrowth. The dam was found to be significantly different from the *Acacia* regrowth.

A Kruskall-Wallis Test was performed to compare the frequencies of the species of each guild across all sites. Significant differences were found for Frugivores, Frugivore/Granivores, Leaf Litter Insectivores, Trunk Gleaning Insectivores, Omnivores, and Foliage Gleaning Insectivores.

Rank Sum Tests were performed to compare each of these individual guilds between each site (Table 4). Significant differences were found between rainforest samples and open sites for 4 guilds; Omnivores, Leaf Litter Insectivores, Frugivores, and Frugivore/Granivores. These guilds also showed significant differences between frequencies of species when rainforest samples were compared to the fragment. Differences were found between rainforest samples and the dam or planting for Foliage Gleaning Insectivores.

Discussion

Classifying species into guild groupings allowed for comparisons of community composition between sites. The dam area and 1995 planting had significantly less diversity of rainforest species as seen by the lack of several guilds. The dam, fragment and planting sites were lacking Leaf Litter Insectivores. This is probably due to a lack of leaf litter available and the drying out of leaf litter due to exposure. Also, the birds in this guild tend to live on the ground and be limited in mobility due to short wings. This would prevent their movement over open areas and restrict access to these sites. As the planting grows, these birds should be seen moving into the planting and fragment sites.

There were no Ground Pouncers found at the dam or planting. These birds feed on insects, including ants and beetles (Blaker *et al.*, 1984) The lack of leaf litter at these sites inhibits the amount of food available to these species. There were also no Trunk Gleaning Insectivores at these sites. This is due to a lack of mature trees available for foraging habitat. As the January 1995 planted trees grow, these birds should move into this site. Use of the dam site will only be possible if the area is revegetated. Also, there were no Frugivores or Frugivore/Granivores found using the plantings. Since these species depend on fruit and seed for survival it is reasonable that they are absent from an area that has no mature trees. However, use of the plantings in the future is very promising due to the mobility of these species.

The trees planted in January 1995 are still very small and cannot support rainforest species. However there are mature rainforest trees on the northern side of the planting and the fragment borders the western side of the planting. Many rainforest species (23) were observed using the fragment. The mature trees on the northern side of the planting were visually observed during planting censusing and many rainforest species were found to be using them. This provides hope that when the trees grow a little more, birds that use the mature trees and fragment will also use the planting.

All but 2 of the 15 Wet Tropics endemic species and subspecies specific to the study site were found at Lake Barrine, Gadgarra State Forest and the *Acacia* regrowth. The 2 exceptions are the Bridled Honeyeater which was only found at Gadgarra and the Macleay's Honeyeater which was not found in the *Acacia*. The only endemic subspecies found at the dam was the Macleay's Honeyeater and no WTESS were found at the planting site. The fragment and *Lantana* were missing 8 and 7 WTESS, respectively. Thus, the Wet Tropics endemic species and subspecies are well represented at Lake Barrine National Park, Gadgarra State Forest and the Acacia regrowth. However, their use of the altered habitats along the corridor site is limited. The isolated species at Lake Barrine may be threatened by extirpation if not able to breed with the birds at Gadgarra State Forest. Therefore more of the corridor should be planted and the presence of these birds along the corridor should continually be monitored. A complete corridor will be useful in conserving these species and preventing extirpation of the isolated populations at Lake Barrine National Park.

Rainforest bird mobility groupings, non-mobile, semi-mobile, and mobile, were established from current data and Burco's spring 1995 data. These groupings were based on the physiology of the birds and where the birds were found in this study and in previous studies. Birds that were only found in mature rainforest habitat were classified as non-mobile. Likewise, birds that were found in all habitats were classified as mobile. Therefore, these groupings are specific to the corridor and not necessarily the same as would be found all over Australia. These lists should be helpful for future researchers to use to identify movement of birds along the corridor and overall success of the corridor. If in the future a non-mobile bird is found in the new plantings, it would help to indicate whether or not the plantings are able to support rainforest species.

Mist netting data included the capture and banding of 121 birds representing 25 different bird species. Some of the birds banded were not audio/visually censused. These birds can be added to the audio/visual census lists, making these lists more complete. There were some problems with mist netting. Several birds had to be released due to stress from being wet or from being in the net too long. Although each site was only mist netted 4 times with 3 days in between mist netting, the number of birds captured declined each time the site was mist netted. This could be due to one of several reasons. It is possible that birds became accustomed to the net sites. In the future I would suggest clearing as little vegetation around the nets as possible. I also suggest checking the nets every 40 to 45 minutes during good weather to minimize human disturbance around the net sites.

We identified a total of 68 birds species during point censusing of which 51 were rainforest species. We were not able to record abundance data. Abundance data would be helpful in determining species population size for each site. The point census data could only be used for frequencies of birds heard (total # days heard/total # days). This means that a bird censused on Day 8 could be the same bird that was heard on Day 6 at the same site. Each species of bird could be counted only once for each site on a particular day. This was due to lack of standardization of calls heard by all 8 researchers. It is recommended that strict guidelines be set and followed from research day 1 on recording abundance of species.

In addition, calls were easier to recognize as field research progressed. It is suggested that more time be given to learning the calls before actual field research begins. The exact areas which fall in the point censusing sites need to be defined from the start of the research. Problems were encountered when birds heard out of the range of the site were recorded as being in the site. This led to non-mobile forest species being recorded in open country areas. Future studies are needed to complete species lists for each of the census sites. Also, this future data will be useful in evaluating the success of the corridor by showing whether all bird species are using the corridor.

Acknowledgements

I would like to thank John Grant and Tony Cummings for their help, patience, and wisdom at the wee hours of the morning. Thank you to Maria Whitehead and Michael George for driving us to the corridor and waking up professors when appropriate. Special thanks goes to Herby and Margaret Egger for allowing us to use their roads, paddocks, and shade trees. Thanks to John Donaghy for use of his watercrossing and paddock. My biggest thanks goes to my fellow bird nerds for endless hours of hard work and entertainment.

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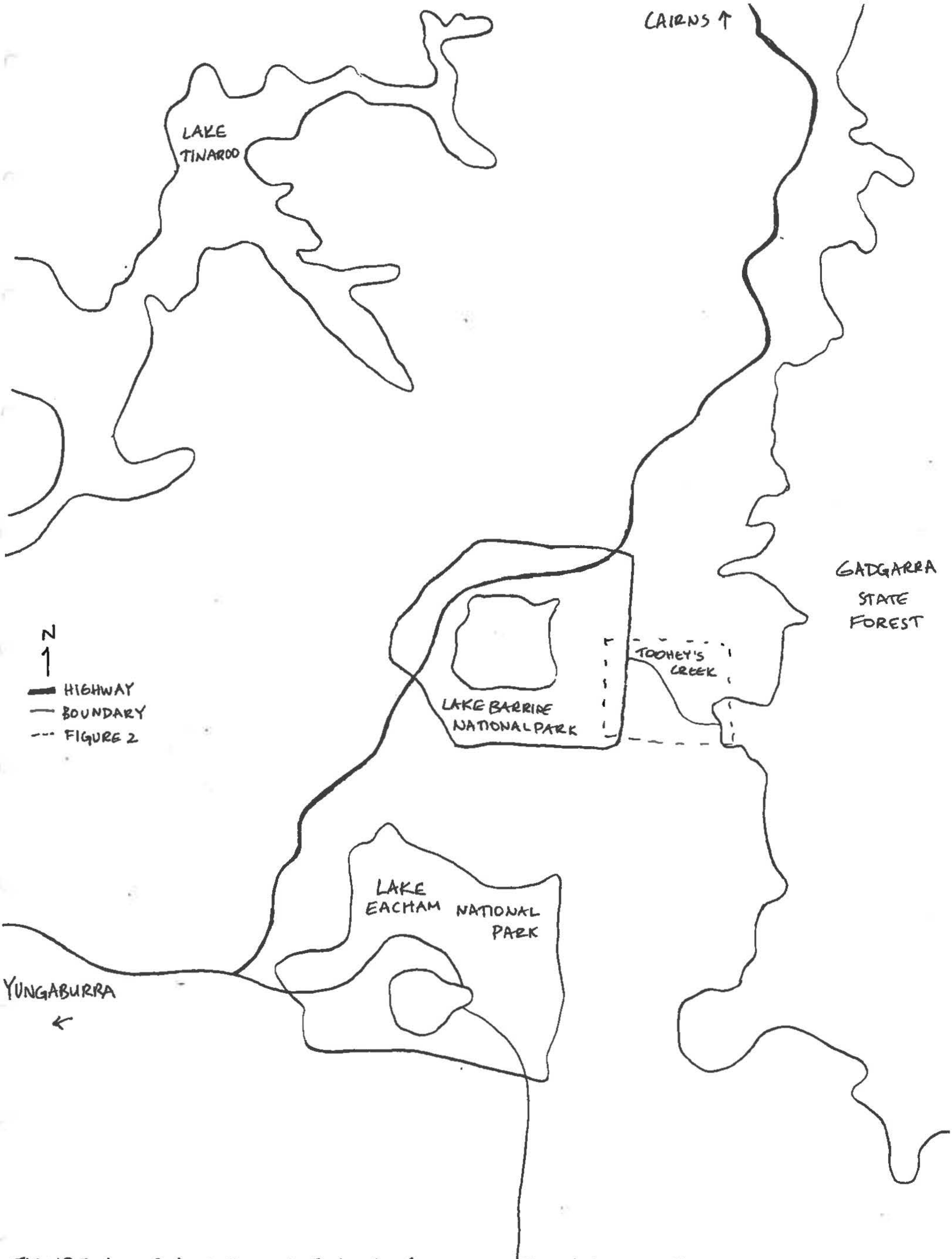

FIGURE 1. Orientation of Toohey's Creek on the Atherton Tableland.

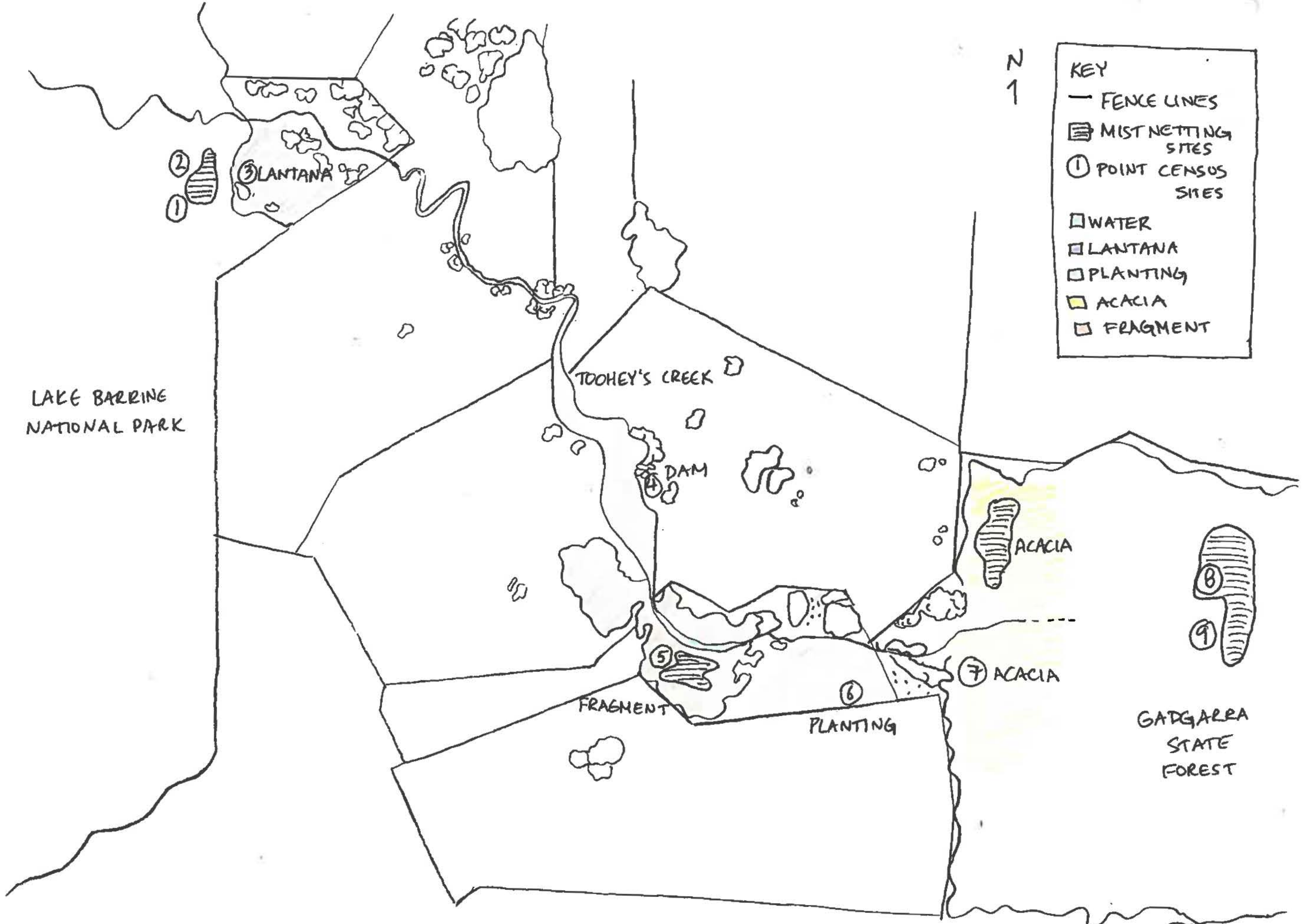
N
KEY
FENCE LINES
MIST NETTING SITES
POINT CENSUS SITES
WATER
LANTANA
PLANTING
ACACIA
FRAGMENT
LAKE BARRINE NATIONAL PARK
LANTANA
TOOHEY'S CREEK
DAM
ACACIA
ACACIA
FRAGMENT
PLANTING
GADGARRA STATE FOREST
1
2
3
4
5
6
7
8
9

Table 1: Mist netting Data

Species Site	LB	A	F	G
Grey-headed Robin	11	1	0	5
Eastern Whipbird	2	0	0	0
Large-billed Scrubwren	9	6	0	7
Spectacled Monarch	1	8	0	1
Lewin's Honeyeater	2	4	1	0
Pale-yellow Robin	2	7	0	0
Little Shrike-thrush	2	9	0	3
Yellow-throated Scrubwren	3	5	0	2
Victoria's Riflebird	1	4	0	0
Mistletoebird	0	1	2	0
Red-browed Firetail	0	1	0	0
White-throated Treecreeper	0	1	0	0
Brown Warbler	0	1	0	0
Bower's Shrike-thrush	0	2	0	0
Golden Whistler	0	1	0	3
Eastern Spinebill	0	1	0	1
Silvereye	0	3	0	0
Black-faced Monarch	0	1	0	0
Pied Monarch	0	1	0	0
Emerald Dove	0	0	2	0
Black Butcherbird	0	0	0	1
Spangled Drongo	0	0	0	1
Australian Fernwren	0	0	0	1
Spotted Catbird	0	0	0	1
Total	32	58	5	26

Sites: LB Lake Barrine; F Fragment; A Acacia; G Gadgarra

Table 2: Number of species per guild for point census sites

Guild Site	1	2	3	4	5	6	7	8	9
Leaf Litter Insectivores	4	4	1	0	0	0	3	4	4
Ground Pouncers	2	2	1	0	1	0	2	2	2
Nectivore/Frugivore/ Granivore	5	6	4	4	5	3	2	6	5
Frugivores	5	5	3	1	5	0	6	5	5
Trunk Gleaner Insectivores	2	3	1	0	2	0	2	3	3
Frugivore/Granivore	5	4	1	1	1	0	5	4	4
Omnivore	5	5	3	1	2	1	4	5	6
Foliage Gleaning Insectivores	9	8	7	2	8	1	9	10	9

1 Lake Barrine 1
2 Lake Barrine 2
3 Lantana
4 Dam
5 Fragment
6 Planting
7 *Acacia*
8 Gadgarra 1
9 Gadgarra 2

Table 3: Rank Sum Test comparing number of species per guild between 2 sites

	Lantana	Dam	Fragment	Planting	*Acacia*
RF	p=0.0259*	p=0.0005*	p=0.0730	p=0.0003*	p=0.3037
Lantana		p=0.0574	p=0.7286	p=0.0074*	p=0.1420
Dam			p=0.0574	p=0.2355	p=0.0052 *
Fragment				p=0.0142*	p=0.2533
Planting					p=0.0009 *

For all sites, n=16, df=15
RF Rainforest (Gadgarra and Lake Barrine combined)

Table 4: Rank Sum Test for frequency of each guild within each site.

Guild	F (n=7, df=6)	O (n=6, df=5)	LLI (n=5, df=4)	TGI (n=3, df=2)	FGr (n=6, df=5)	FG (n=12, df=11)
RF V. 3	0.0189*	0.0130*	0.0079*	0.05*	0.0076*	t=116
RF V. 4	0.0131*	0.0022*	0.004*	0.05*	0.0076*	t=82*
RF V. 5	0.1142	0.0076*	0.004*	0.05*	0.0206*	t=135
RF V. 6	0.0020*	0.0022*	0.004	0.05*	0.0011*	t=88*
RF V. 7	0.5574	0.3355	0.3690	0.2	0.5833	t=145
1 V. 2	0.3690	0.3355	0.4603	0.5	0.4145	t=146
8 V. 9	0.2817	0.4978	0.5556	0.5	0.2684	t=142
B V. G	0.3690	0.5833	0.4603	0.35	0.4145	t=141

All values are p values unless noted; * indicates significance.

Abbreviations:
RF Rainforest (Barrine and Gadgarra combined)
1 Lake Barrine 1 | 4 Dam | 7 *Acacia*
2 Lake Barrine 2 | 5 Fragment | 8 Gadgarra 1
3 Lantana | 6 Planting | 9 Gadgarra 2
B Barrine | G Gadgarra
F Frugivore | O Omnivore | LLI Leaf Litter Insectivore
TGI Trunk Gleaning Insectivore | FGr Frugivore/Granivore
FG Foliage Gleaner

Appendix 1: Point Census Species List

COMMON NAME	*SCIENTIFIC NAME*	1	2	3	4	5	6	7	8	9
Australian fernwren	*Crateroscelis gutturalis*	x	x					x	x	x
Chowchilla	*Orthonyx spaldingii*	x	x					x	x	x
Eastern whipbird	*Psophodes olivaceus*	x	x					x	x	x
Red-necked crake	*Rallina tricolor*									x
Yellow-throated scrubwren	*Sericornis citreogularis*	x	x	x					x	
Grey-headed robin	*Poecilodryas albispecularis*	x	x	x				x	x	x
Pale-yellow robin	*Tregallasia capito*	x	x			x		x	x	x
Bridled honeyeater	*Lichenostomus frenatus*								x	x
Dusky honeyeater	*Myzomela obscura*	x	x		x	x	x		x	x
Eastern spinebill	*Acanthorhynchus tenuirostris*		x						x	x
Graceful honeyeater	*Meliphaga gracilis*	x	x							
Lewin's honeyeater	*Meliphaga lewinii*	x	x	x	x	x	x	x	x	x
Macleay's honeyeater	*Xanthotis macleayana*	x	x	x	x	x			x	x
Mistletoebird	*Dicaeum hirundinaceum*			x		x				
Silvereye	*zosterops lateralis*	x	x	x	x	x	x	x	x	
Channel-billed cuckoo	*Scythrops novaehollandiae*							x		
Figbird	*Sphecotheres viridis*			x	x	x			x	x
Rose-crowned fruit-dove	*Ptilinopus regina*	x	x					x		
Spotted catbird	*Ailuroedus melanotis*	x	x	x		x		x	x	x
Superb fruit-dove	*Ptilinopus superbus*	x	x			x		x	x	x
Tooth-billed catbird	*Ailuroedus dentirostris*	x	x			x		x	x	x

COMMON NAME	*SCIENTIFIC NAME*	1	2	3	4	5	6	7	8	9
Wompoo pigeon	*Ptilinopus magnificus*	x	x	x		x		x	x	x
Pied monarch	*Arses kaupi*		x						x	x
Victoria's riflebird	*Ptiloris victoriae*	x	x	x		x		x	x	x
White-throated treecreeper	*Cormobates leucophae*	x	x			x		x	x	x
Australian king parrot	*Alisterus scapularis*	x	x					x	x	x
Brown cuckoo-dove	*Macropygia amboinesis*	x	x	x	x	x		x	x	x
Crimson rosella	*Platycercus elegans*	x								
Emerald dove	*Chalcophaps indica*						x	x		
Sulphur-crested cockatoo	*Cacatua galerita*	x	x				x	x	x	
White-headed pigeon	*Columba leucomela*	x	x				x			
Australian brush turkey	*Alectura lathami*									x
Black butcherbird	*Cracticus quoyi*	x	x	x				x	x	x
Laughing kookaburra	*Dacelo novaeguineae*	x	x					x	x	x
Orange-footed scrubfowl	*Megapodius reinwardt*	x	x					x	x	x
Pied currawong	*Strepera graculina*	x	x	x		x	x	x	x	x
Spangled drongo	*Dicrurus bracteatus*	x	x	x	x		x	x	x	x
Black-faced monarch	*Monarcha melanopsis*	x	x	x	x	x			x	x
Bower's shrike-thrush	*Colluricincla boweri*	x	x	x		x		x	x	x
Brown warbler	*Gerygone mouki*	x	x	x		x		x	x	x
Cicadabird	*Corancina tenuirostris*	x	x	x	x	x			x	x
Fan-tailed cuckoo	*Cuculus flabelliformis*							x	x	x
Golden whistler	*Pachycephala pectoralis*	x	x	x		x		x	x	x

COMMON NAME	*SCIENTIFIC NAME*	1	2	3	4	5	6	7	8	9
Large-billed scrubwren	*Sericornis magnirostris*	x	x	x		x		x	x	x
Little shrike-thrush	*Colluricincla megarhyncha*	x	x	x		x	x	x	x	x
Shining bronze cuckoo	*Chrysococcyx lucidus*							x	x	
Spectacled monarch	*Monarcha trivirgatus*	x	x			x		x	x	x
White-eared monarch	*Monarcha leucotis*							x		
Yellow-breasted boatbill	*Machaerirhynchus flaviventer*	x								x

SITE KEY:

1 = BARRINE #1
2 = BARRINE #2
3 = LANTANA
4 = DAM
5 = FRAGMENT
6 = PLANTING
7 = ACACIA
8 = GADGARRA #1
9 = GADGARRA #2

Appendix 2.

Point Census Frequencies

Species Site	1	2	3	4	5	6	7	8	9
Leaf Litter Insectivores									
Chowchilla	0.5	0.83	0	0	0	0	0.58	0.58	0.83
Australian Fernwren	0.08	0.08	0	0	0	0	0.08	0.08	0.08
Red-necked Crake	0	0	0	0	0	0	0	0	0.08
Eastern Whipbird	0.92	0.75	0	0	0	0	0.92	0.83	0.75
Yellow-throated Scrubwren	0.08	0.17	0.08	0	0	0	0	0.08	0
Ground Pouncers									
Pale-yellow Robin	0.42	0.17	0	0	0.25	0	0.33	0.08	0.08
Grey-headed Robin	1	0.92	0	0	0	0	0.5	0.67	0.92
Nectivore/Insectivore/Frugivore									
Macleay's Honeyeater	0.58	1	0.17	0.08	0.58	0	0	0.67	0.5
Graceful Honeyeater	0.08	0.17	0	0	0	0	0	0	0
Eastern Spinebill	0	0.08	0	0	0	0	0	0.25	0.33
Bridled Honeyeater	0	0	0	0	0	0	0	0.33	0.08
Mistletoebird	0	0	0.33	0	0.08	0	0	0	0
Silvereye	0.08	0.33	0.83	0.5	0.17	0.5	0.17	0.08	0
Dusky Honeyeater	0.17	0.17	0	0.08	0.08	0.08	0	0.08	0.08
Lewin's Honeyeater	1	1	0.75	0.75	1	0.16	0.66	0.75	0.58
Frugivore									
Rose-crowned Fruit-Dove	0.42	0.25	0	0	0	0	0.25	0	0
Channel-billed Cuckoo	0	0	0	0	0	0	0.08	0	0
Superb Fruit-Dove	0.67	0.83	0	0	0.08	0	0.58	0.5	0.42
Spotted Catbird	0.67	0.75	0.08	0	0.17	0	0.75	0.83	0.67
Figbird	0	0	0.08	0.58	0.25	0	0	0.08	0.08
Tooth-billed Catbird	0.58	0.17	0	0	0.08	0	0.08	0.17	0.83
Wompoo Fruit-Dove	0.58	0.92	0.08	0	0.33	0	0.58	0.42	0.67
Trunk Gleaning Insectivore									
Pied Monarch	0	0.25	0	0	0	0	0	0.17	0.17
Victoria's Riflebird	0.58	0.5	0.08	0	0.08	0	0.33	0.17	0.5
White-throated Treecreeper	0.33	0.42	0	0	0.08	0	0.33	0.42	0.17
Frugivore/Granivore									
Australian King Parrot	0.42	0.33	0	0	0	0	0.75	0.17	0.08
Crimson Rosella	0.08	0	0	0	0	0	0	0	0
Emerald Dove	0	0	0	0	0	0	0.17	0.25	0
White-headed Pigeon	0.08	0.08	0	0	0	0	0.08	0	0
Sulphur-crested Cockatoo	0.25	0.17	0	0	0	0	0.17	0.17	0.17
Brown Cuckoo-Dove	0.92	0.75	0.17	0.08	0.67	0	0.75	0.83	0.83
Omnivore									
Australian Brush-turkey	0	0	0	0	0	0	0	0	0.08
Black Butcherbird	0.33	0.5	0.08	0.08	0	0	0.42	0.67	0.33
Orange-footed Scrubfowl	0.75	0.67	0	0	0	0	0.92	0.33	0.5
Spangled Drongo	0.33	0.08	0.08	0.08	0.17	0	0.17	0.17	0.08
Laughing Kookaburra	0.17	0.17	0	0	0	0	0.17	0.08	0.08
Pied Currawong	0.5	0.25	0.16	0	0.08	0.08	0.58	0.66	0.5
Foliage Gleaning Insectivore									
Large-billed Scrubwren	0.5	0.17	0.08	0	0.42	0	0.33	0.33	0.42

Shining Bronze-Cuckoo	0	0	0	0	0	0	0.08	0.25	0
Spectacled Monarch	0.67	0.67	0	0	0.17	0	0.33	0.75	0.83
Golden Whistler	0.92	0.92	0.25	0	0.25	0	1	0.75	0.5
Little Shrike-thrush	0.5	0.67	0.17	0	0.83	0.08	0.67	0.5	0.5
Cicadabird	0.25	0.25	0.17	0.25	0.08	0	0	0.42	0.17
Fan-tailed Cuckoo	0	0	0	0	0	0	0.17	0.08	0.08
Varied Triller	0.25	0.42	0	0.17	0.25	0	0.25	0.25	0.08
White-eared Monarch	0	0	0	0	0	0	0.08	0	0
Bower's Shrike-thrush	0.25	0.17	0.08	0	0.17	0	0.33	0.25	0.42
Yellow-breasted Boatbill	0.08	0	0	0	0	0	0	0	0
Brown Warbler	0.92	0.92	0.42	0	1	0	0.92	0.92	0.75
Other species									
Rainbow Lorikeet	0	0.08	0	0	0	0	0	0	0
Australian Magpie	0	0	0	0.5	0	0.08	0	0	0
Black-faced Cuckoo-shrike	0	0	0	0	0	0	0	0	0
Brown Quail	0	0	0	0	0.08	0	0	0	0
Chestnut-breasted Mannikin	0	0	0.67	0	0	0	0	0	0
Common Myna	0	0	0	0.08	0	0	0	0	0
Dusky Moorhen	0	0	0	0.58	0	0	0	0	0
Golden-headed Cisticola	0	0	0.33	0.42	0	0.17	0	0	0
Magpie-lark	0	0	0	0.25	0	0	0	0	0
Masked Lapwing	0	0	0	0.08	0	0	0	0	0
Pacific Black Duck	0	0	0	0.33	0	0	0	0	0
Peaceful Dove	0	0	0	0.33	0	0	0	0.17	0.08
Purple Swamphen	0	0	0	0.75	0	0	0	0	0
Red-backed Fairywren	0	0	0.08	0.92	0	0.42	0	0	0
Red-browed Firetail	0	0	0.58	0	0	0.75	0	0	0
Tawny Grassbird	0	0	0	0.08	0	0	0	0	0
Willy Wagtail	0	0	0	0.67	0	0	0	0	0
White-faced Heron	0	0	0	0	0	0	0	0	0

Appendix 3: Foraging Guild Groupings and Endemic Species

Leaf Litter Insectivores
Australian Fernwren *
Chowchilla *
Eastern whipbird +
Red-necked Crake
Yellow-throated Scrubwren +

Ground Pouncer
Grey-headed Robin *
Pale-yellow Robin +

Nectivore/Insectivore/ Frugivore
Bridled Honeyeater *
Dusky Honeyeater
Eastern Spinebill
Graceful Honeyeater
Lewin's Honeyeater
Macleay's Honeyeater *
Mistletoebird
Silvereye

Frugivore
Channel-billed Cuckoo
Figbird
Rose-crowned Fruit-Dove
Spotted Catbird *
Superb Fruit-Dove
Tooth-billed Catbird *
Wompoo Pigeon

Trunk Gleaning Insectivore
Pied Monarch *
Victoria's Riflebird *
White-throated Treecreeper +

Frugivore/Granivore
Australian King Parrot
Brown Cuckoo-Dove
Crimson Rosella
Emerald Dove
Sulphur-crested Cockatoo
White-headed Pigeon

Omnivore
Australian Brush-turkey
Black Butcherbird
Laughing Kookaburra
Orange-footed Scrubfowl
Pied Currawong
Spangled Drongo

Foliage Gleaning Insectivore
Black-faced Monarch
Bower's Shrike-thrush *
Brown Warbler
Cicadabird
Fan-tailed Cuckoo
Golden Whistler
Large-billed Scrubwren +
Little Shrike-thrush
Shining Bronze-Cuckoo
Spectacled Monarch
White-eared Monarch
Yellow-breasted Boatbill

*** Endemic Species**
+ Endemic Subspecies

Appendix 4: Bird Mobility Groupings

Non-Mobile Rainforest Species
Australian Fernwren
Bridled Honeyeater
Chowchilla
Eastern Spinebill
Eastern Whipbird
Fan-tailed Cuckoo
Graceful Honeyeater
Grey-headed Robin
Orange-footed Scrubfowl
Pied Monarch
Rose-crowned Fruit-Dove
White-eared Monarch
Yellow-throated Scrubwren

Semi-Mobile Rainforest Species
Black Butcherbird
Bower's Shrike-thrush
Brown Warbler
Golden Whistler
Large-billed Scrubwren
Little Shrike-thrush
Macleay's Honeyeater
Mistletoebird
Pale-yellow Robin
Shining Bronze-Cuckoo
Spectacled Monarch
Spotted Catbird
Superb Fruit-Dove
Tooth-billed Catbird
White-headed Pigeon
White-throated Treecreeper
Wompoo Fruit-Dove
Yellow-breasted Boatbill

Mobile Rainforest Species
Australian King Parrot
Black-faced Monarch
Brown Cuckoo-Dove
Cicadabird
Dusky Honeyeater
Emerald Dove
Figbird
Laughing Kookaburra
Lewin's Honeyeater
Pied Currawong
Silvereye
Spangled Drongo
Sulphur-Crested Cockatoo
Varied Triller
Victoria's Riflebird

Open/Grassland Wetland Species
Australian Magpie
Black-faced Cuckoo-shrike
Brown Quail
Chestnut-breasted Mannikin
Common Myna
Dusky Moorhen
Golden-headed Cisticola
Magpie-lark
Masked Lapwing
Pacific Black Duck
Peaceful Dove
Purple Swamphen
Red-backed Fairywren
Red-browed Firetail
Tawny Grassbird
Willy Wagtail
White-faced Heron

The use of urban parks by chaparral-requiring bird species in Redlands, California

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April 29, 1996
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Abstract

This study from February through April 1996 examines bird species present in the parks of the city of Redlands, California. Park habitat ranged from chaparral vegetation to grass. Species composition in each park was determined by visual censuses. Twenty five different bird species were observed with 4 being classified as chaparral-requiring species. As the amount of chaparral habitat increased, the number of species and chaparral-requiring species decreased. As use of the parks by humans increased, the numbers of species observed decreased. The parks were evaluated to determine the if the use of corridors would be helpful in maintaining present populations of chaparral-requiring species. Corridors were determined to be useful when planted to maintain present populations of chaparral species and continuous scrub habitat. Parks landscaped with grass and other vegetation for human use were determined to have fewer or no species of chaparral birds present. Thus, in an urban landscaped habitat, the use of corridors would be expensive and futile by attempting to reintroduce birds that cannot survive in the habitat.

Introduction

Habitat fragmentation occurs when a large area of habitat is divided into many smaller patches and includes loss of original habitat as well as increased isolation of the remaining patches. Habitat fragmentation occurs naturally by such disturbances as windfall or fire. However, in today's world, habitat fragmentation has increased dramatically due to an increase in human land use (Andrén, 1994). The ultimate effects of habitat fragmentation are a decrease in the populations of species as well as a loss of species diversity.

The initial ideas and knowledge on the effects of habitat fragmentation came from the study of islands, relatively small, but complex study areas where populations could be easily identified. These studies led to the theory of island biogeography, which suggests that the number of species on an oceanic island represents a balance between processes of immigration and extinction (Wilcove, et al., 1986). The equilibrium number of species depends upon the characteristics of the island, primarily its area and isolation from other habitat patches (MacArthur & Wilson, 1967). Species relaxation describes the death of species due to there being more species present than the habitat is able to maintain. Species relaxation occurs on islands due to reduced habitat availability as well as a decrease in habitat diversity. In any fragment, species that require native vegetation, large habitat areas, or exist at low densities will be first affected by species relaxation (Saunders, 1991). When small populations exist for longer than a few generations, their long term survival is threatened by inbreeding depression due to increased homozygosity (Soulé, 1988; Laurance, 1991). Increases in homozygosity increase the chances that a detrimental gene will be expressed and leads to decreased variability in offspring which increases the chance of death involved with any environmental changes (Ralls, et al., 1986).

This same effect can be seen in fragmentation of once continuous natural habitats. In the temperate zone, habitat fragmentation has been occurring for at least one thousand years due to the proliferation of human land use (Wilcove, et al., 1986). The remaining patches are considered 'habitat islands' due to unfriendly surrounding landscape. Surviving species in these patches are thought to be somewhat resistant to habitat fragmentation due to the species occurring at higher densities and having wider distributions. If local extinction rates are high, then it seems that recolonization can occur from other fragments.

However, temperate communities have shown decreases in population due to habitat fragmentation. Habitat that seems to be uniform is actually a mosaic of different habitats. Remaining patches may lack some of the original habitat types. For example, the Louisiana Waterthrush requires open water for survival. Remaining habitat patches that do not provide a suitable water supply lack the presence of these birds (Wilcove, et al., 1986). Some species require two or more habitat types for survival. Fragmentation may make it impossible for them to move between habitats. The Blue-gray Gnatcatcher moves from deciduous oak woodlands to chaparral and live oaks over the course of a breeding season (Wilcove, et al., 1986). Fragmentation could cause the death of the species locally due to lack of suitable breeding habitat.

In the species-diverse tropical rainforest habitat, fragmentation has been determined to be detrimental to faunal diversity (Lovejoy, *et al.* 1986). This applies in particular to rainforest birds due to their strict needs for rainforest habitat for breeding and foraging and their lack of mobility. Lack of mobility arises from shortened wing spans and adaptations to live on the ground. Another problem associated with habitat fragmentation in a tropical zone is that many species are endemic to very small habitat ranges. Destruction of habitat can easily cause the extirpation of these species due to a lack of being able to recolonize. Other communities of these birds do not exist.

What are the effects of habitat fragmentation on the long term viability of specialized avian populations in other ecosystems? Many Mediterranean scrub type habitats are characterized by high species diversity and specialized avian populations. Several birds require this *chaparral* habitat for breeding purposes and some birds are limited in mobility due to short wings (Terres, 1980). This is accented by the fact that they forage almost exclusively within the scrub, ground litter, or on the edges of the scrub. Thus it would seem that habitat fragmentation would have a significant effect on the viability and diversity of these populations.

In southern California, Mediterranean type scrub extends from sea level to about 2000 meters in some places. This chaparral vegetation is a dense, interlocking network of shrubs and trees, usually less than 2.5 meters tall, that are adapted to hot, dry summers and mild, wet winters. One study of remaining chaparral habitat in San Diego County has determined that in isolated habitat patches, the area of chaparral remaining and the age of the isolated patch influence the number of chaparral-requiring birds observed to be utilizing the habitat (Soulé, *et al.* 1988). Although the patches were isolated by urban development, they still contained chaparral habitat. What effect would habitat fragmentation and conversion to an urban landscape have on chaparral bird species?

This study focuses in on the effects of habitat fragmentation in an urban context with the remaining land having been converted to city parks. The San Bernardino Valley, like most of Southern California, once had extensive areas of chaparral type vegetation. Today, however, the area of this chaparral vegetation has been fragmented dramatically due to urban development. Most of what remains in the San Bernardino Valley is on land that was spared only due to steep slopes that discouraged development. Part of this valley is now the city of Redlands. The parks in the city are essentially the last remaining areas of open land, however, they have been landscaped and converted to accommodate humans. One park has been partially landscaped with native vegetation while the others have been completely converted to urban vegetation. Thus the issues affecting chaparral bird species include both habitat fragmentation and human use. Does development of parks for human use further damage the already fragmented habitat to the extent that native chaparral birds species can no longer utilize the land? This study examined the existing bird communities in the various parks of the city of Redlands with an emphasis on whether any chaparral-requiring bird species utilize these converted habitats and whether these parks will allow for viable populations of these birds in the future.

Methods

Site Description

There were four park sites studied in the city of Redlands, California (see Figure 1); Caroline Park, Prospect Park, Ford Park, and Sylvan Park. With the exception of Caroline Park, all sites are surrounded by developed land and city streets. All parks have been developed in some way to attract local residents to utilize their resources.

Caroline Park is located at Sunset Drive and Poppy Road. The land for the park was set aside in 1929 but was not developed until 1988. This park covers 17 acres of canyons and meadows and is partially landscaped (about 40%) with native California vegetation. This park is planted in one area with ornamentals and is irrigated. There are walking and riding trails through the park, but no other buildings or play areas. Trees in the park include sycamore (Platanus racemosa), wild lilac (Ceanothus), and palm trees. Scrub type plants include white and black sage, manzanita ground cover, and wild lilac ground cover. Caroline Park borders undeveloped San Timeteo Canyon on the south and east sides.

Prospect Park, at the corner of Highland and Cajon, was formed in 1896 and covers 40 acres. This area includes 26 acres of orange groves while the remaining 14 acres are vegetated with eucalyptus, oleander, periwinkle, palm trees, and wild berry ground cover. This park is dissected with dirt roads and has a community theater in the middle.

Prospect Park is embedded in a residential area. The closest chaparral vegetation is San Timeteo Canyon, approximately 2 miles away.

Ford Park, located at Parkford Drive and Redlands Boulevard, covers 20 acres and was formed in 1965. Vegetation includes palm trees and oleander. Ford Park has two ponds which provide a permanent water supply and a home for many waterfowl. This park also was designed for recreational purposes, with tennis courts and picnic tables, and embedded in a residential area. There is open undeveloped land within a mile of the park, yet native chaparral vegetation is approximately 2 miles away.

Sylvan Park, at the corner of University and Colton Avenues, was formed in 1911 and the study site included portions of the University of Redlands campus which borders the park. The park extends 23 acres and the primary vegetation is grass. There are scattered trees around the park, including such species as palm trees and oak trees. The Zanja irrigation ditch flows through the park. The University of Redlands has a variety of vegetation including oak trees and palm trees. The park is in the mddle of a residential area, yet there is open land south-east of the University. The closest chaparall area is Mill Creek, about 3 miles away.

Birds

All bird species censused in each study area were recorded. The only birds excluded from the study were waterfowl and raptors. The remaining birds were broken down into two categories, chaparral species and all other species. The classification of chaparral species (Table 1) was taken from Soulé *et al.* (1988) in which 8 birds were classified as chaparral-requiring species due to the requirement of chaparral habitat for breeding. Most of the remaining species utilize chaparral habitats but also feed and breed in non-native habitats such as yards and parks.

Table 1. Common and scientific names of chaparral-requiring species.

Bewick's Wren (*Thryomanes bewickii*)
Black-tailed Gnatcatcher (*Polioptila melanura*)
Cactus Wren (*Camplyorhynchus brunneicapillus*)
California Quail (*Callipepla californica*)
California Thrasher (*Toxostoma redivivum*)
Greater Roadrunner (*Geococcyx californianus*)
Rufous-sided Towhee (*Pipilo erythrophthalmus*)
Wrentit (*Chamaea fasciata*)

Census Techniques

The objective was to provide complete species lists of the birds in each study area. The study sites were chosen for their diversity of habitats and location within the city to obtain a representative sample of the city parks as a whole. Censuses were conducted from February through April, 1996. Each site was censused at least four times. Researchers walked slowly through the area, recording the presence of each species seen. Each site was censused for at least an hour each time. All censusing was done between 7 AM and 8:30 AM. Birds were only noted for presence or absence, there was no attempt to identify densities of the birds present. Sites were not observed during wet weather conditions due to altered frequencies of birds at these times.

Data Analysis

Statistical analyses were performed using StatView (Abacus Concepts, Inc., Berkeley, CA, 1992) and Microsoft Excel.

Results

Census Data

All biogeographic data is shown in Table 2. There were 29 different bird species censused at the four study sites (See Table 3). The greatest number of bird species (19) was seen at Caroline Park while Prospect Park had only 10 bird species present. Only 4 of the 8 chaparral species were observed. The California Thrasher, Rufous-sided Towhee, and Wrentit were observed at Caroline Park. Although there were no California Quail censused at Caroline Park, two neighbors of the park indicated that these birds had been seen in the park within the last year. Prospect Park had two chaparral species, a Bewick's Wren and a Rufous-sided Towhee. Both of these birds were observed in a section of the park which was vegetated with wild berry ground cover. Ford Park had only one chaparral species present, a Bewick's Wren. There were no chaparral species censused at Sylvan Park.

Table 2. Biogeographic data.

Park	Number of species	Number of chaparral species	Area (acres)	Chaparral Area (acres)	Age (years)
Sylvan	11	0	23	0	85
Ford	13	1	20	0	31
Prospect	10	2	40	0	100
Caroline	19	3	17	6.8	8

Species - Area Relationships

The relationship between species and area can be seen in Figure 2. As the area of the park increased, the amount of species decreased. For example, there were 19 different species observed at the 17 acre Caroline Park while only 10 species were observed at the 40 acre Prospect Park. The Pearson product-moment correlation coefficient between park area and number of species was -0.715 (Table 4). This confirms the visible negative relationship between these variables. There was not a strong correlation (r=0.025) between the number of chaparral species observed and the area of the park.

Table 3. The distribution of bird species.*

Bird Species	Sylvan Park	Ford Park	Prospect Park	Caroline Park
Acorn Woodpecker	X		X	
American Crow	X	X	X	X
American Robin	X			
Anna's Hummingbird			X	X
Band-tailed Pigeon	X	X		
Bewick's Wren		X	X	
Black Phoebe		X		
Bushtit	X			X
California Thrasher				X
Cedar Waxwing				X
Chipping Sparrow				X
Dark Eyed Junco				X
European Starling	X	X		X
House Finch	X	X	X	X
House Wren			X	
Lesser Goldfinch	X	X	X	X
Mountain Chickadee		X		
Northern Flicker		X		
Northern Mockingbird				X
Nuttall's Woodpecker	X			
Purple Finch		X		X
Ruby-crowned Kinglet		X		
Rufous-sided Towhee			X	X
Say's Phoebe				X
Scrub Jay	X	X	X	X
Western Bluebird				X
White-crowned Sparrow				X
Wrentit				X
Yellow-rumped Warbler	X	X	X	X

*Scientific names of birds are listed in Appendix 1; Chaparral species are underlined.

Caroline Park had the only area of chaparral habitat and the largest number of chaparral species. There was a positive correlation (r=0.775) seen between the number of chaparral species censused and the area of chaparral within the parks. An estimated 40% of the total area of Caroline Park had chaparral vegetation corresponding to 6.8 acres of chaparral vegetation in the 17 acre park. This was also the only park which was bordered by native chaparral vegetation. The product-moment correlation coefficient shows a strong positive relationship ($r=0.951$, $p \leq 0.05$) between the number of species censused when compared to chaparral area. There were 19 species observed in Caroline Park while only 10-13 observed in parks without chaparral vegetation.

Table 4. Pearson product-moment correlation coefficients between variables.

	Species	Chaparral Species	Area	Chaparral Area	Age
Species	1				
Chaparral Species	0.673	1			
Area	-0.715	0.025	1		
Chaparral Area	0.951	0.775	-0.518	1	
Age	-0.906	-0.480	0.825	-0.734	1

$p \leq 0.05$ for coefficients ≥ 0.950; $p \leq 0.10$ for coefficients ≥ 0.900.

Species - Age Relationships

The relationship between species and age of the park can be seen in Figure 3. As the age of the park increased, the number of species observed decreased. The product-moment correlation coefficient gave a value of -0.906 (Table 4, $p \leq 0.10$). Caroline Park had the most species, yet was the youngest park. The park has only been developed for 8 years even though the land was donated 67 years ago. The land was left relatively untouched until developed by the city. Prospect Park was the oldest park yet only 10 different species were observed. There was also a negative correlation (from Table 4, r = -

0.480) between the number of chaparral species observed and the age of the parks. The older the park, the fewer chaparral species observed.

Figure 2. The relationship between number of species and the area of the park.

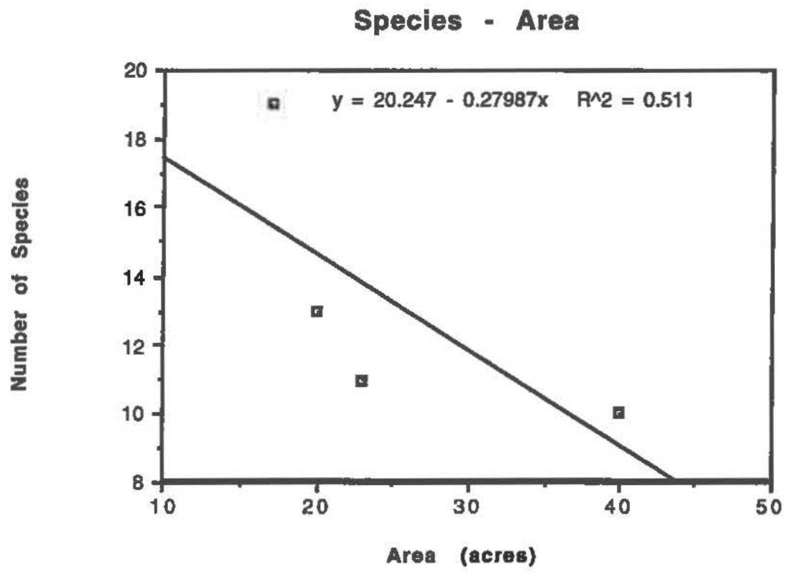
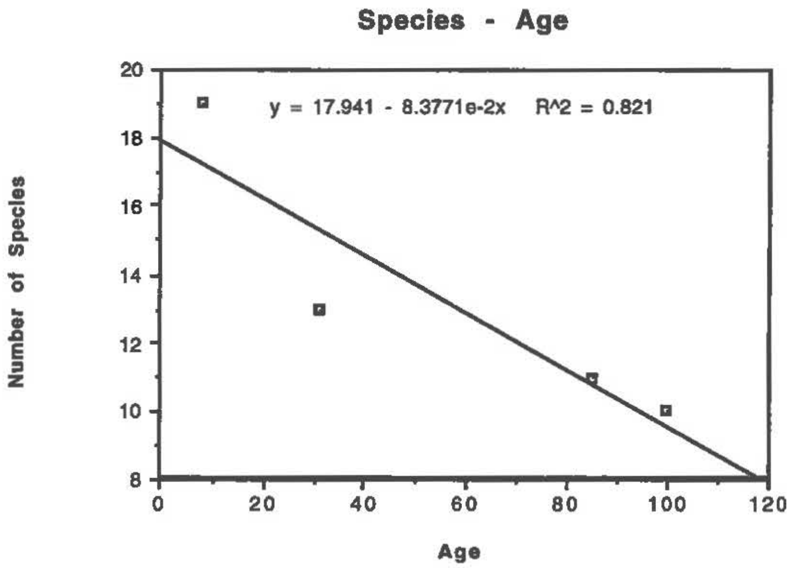


Figure 3. The relationship between the number of species and the age of the park.



Discussion

Half of the 8 chaparral requiring species were not observed in the survey of these four parks in Redlands. This may indicate that chaparral requiring species cannot survive in an urban context. However, it may not be accurate to say that the populations of the birds in these parks have undergone extinction due in part to habitat fragmentation by human land use. It is possible that these birds were not present at the location of the park before fragmentation. Two of these species, the California Quail and Greater Roadrunner, travel mainly by foot. Quail will only fly if forced and roadrunners have short, rounded wings and long legs that are adapted to allow them to run quickly rather than fly. Due to these circumstances, if the species were not present before fragmentation, then odds are that the birds would not be able to travel to the parks once fragmentation occurred. The other two missing chaparral species, the Cactus Wren and the Black-tailed Gnatcatcher, do not have these flight restrictions, but are limited by their foraging and breeding necessities as well as by being desert birds. Thus these birds are not common residents of the area of Redlands. The Cactus wren forages in ground litter and is limited to shrubs for nesting sites. The Black-tailed Gnatcatcher is rarely visible due to foraging in shrubs and living in thickets. If absent from the fragmented habitat before isolation, it is possible that they would never move into the park since this would require crossing of open or developed land.

The lack of observation of 4 of the 8 chaparral species could also be due to sample size. Each park was observed only 4 times. It is possible with increased observations that these species would eventually be observed. The California Quail and Greater Roadrunner are residents of the area but observation is uncommon. They have been observed in scrub habitats or in San Timeteo Canyon. There is some evidence that at least one of the missing chaparral species was present in Caroline Park in past years. Residents who walk in the park indicated that quail were observed in the park sometime within the last year. They also indicated that the numbers of quail seen have been decreasing rapidly in the past few years.

Caroline Park is the youngest park and it showed the greatest number of species present. However there are other factors that effect correlations between age of the park and number of species present. The oldest parks are the parks found in the middle of residential areas. The distances from these parks to native chaparral vegetation is at least 2 miles. On the other hand, Caroline Park had the least area and was bordered by San Timeteo Canyon. This park also has the most chaparral vegetation. Thus it can be reasoned that the greatest number of chaparral species were observed at Caroline Park due to ideal habitat and the ability to easily move from the continuous canyon habitat to the fragmented park habitat.

Species diversity was also observed to decrease with increasing age of the park. This correlation seems to be best explained in relation to human park usage. One of the reasons for building a park is to maintain a natural, aesthetically pleasing environment for human usage. As the resources in the park are developed for this purpose, more people will use the park, causing the disruption of the native fauna of the park. Caroline Park is the youngest park in terms of being developed by the city and gets used the least by the community. This could be due to its location, lack of facilities designed to attract the community, or by the fact that some of the citizens of the community do not know that it exists.

The other parks are older and get much more use by the community. Thus there is increased disruption to the natural habitat. The birds present have to compete with humans for habitat. Prospect Park, the oldest at 100 years, has a theater in the middle which is used year-round and thus provides the community with a reminder that the park exists and an event that brings them to the park. Sylvan Park and Ford Park are 85 and 31 years old, respectively. Sylvan Park is often in use by the community for a variety of occasions including weddings, outings by the local elementary school, and holiday picnics. An added attraction is the vast open area with a baseball field and swimming pool. Ford Park is in constant contact with humans due to tennis courts, a playground, and two ponds. The birds present at these parks have to co-habitate with the humans that use the park. This also means that the birds must live with the pets that humans bring to the parks or that roam free in the parks from neighboring houses. Dogs can be particularly harmful to the survival of chaparral species due to the bird's shortened wing spans and limitations in mobility.

Prospect park was the oldest park and had the least number of total species present, yet it had the second highest number of chaparral species present. This indicates that while it is possible that overall species diversity has decreased over time, the chaparral species present have not been affected as much as they were in other parks. All chaparral birds observed at this park were foraging in wild berry ground cover vegetation. Although this is not chaparral vegetation, the resources available seemed to mimic chaparral vegetation. They provided a continuous, shrub-like ground cover similar to that of chaparral scrub. One of the species present, the Rufous-sided Towhee, was particularly suited to this environment due to its preference for foraging in thickets and eating berries.

The fact that chaparral-requiring species were present in parks that had vegetation similar to natural chaparral vegetation is promising for the future. This indicates that there is a possibility that revegetation with chaparral scrub vegetation or vegetation that mimics chaparral scrub will be helpful in conserving future biodiversity. There are several ways in which revegetation can assist in conserving the biodiversity of fragmented areas. Buffer zones can be planted around the fragmented area to decrease the effects of external factors such as weed invasion and wind damage in the fragmented area (Hobbs, 1993). Another idea is to increase the amount of habitat available. The main problem with both of these ideas is that the areas have already been fragmented due to increased human development. Thus these parks are surrounded by urban development and large areas of land surrounding them are not available. Other problems include factors such as what is the necessary width for a buffer zone and to what extent can fauna utilize revegetated areas. That is, are the species still restricted to native habitat for foraging or breeding?

The most promising idea over the past few years for overcoming the effects of habitat fragmentation is the development of corridors. A corridor is a strip of planted native vegetation between existing fragments for the purpose of wildlife conservation (Lindenmeyer, 1994). Corridors potentially allow for physical movement of birds and genetic interchange between bird populations. Corridors can increase immigration to a fragment, increase foraging area and increase the mix of habitats available to the animals using the corridor (Noss, 1987). In this urban situation, a corridor would require the least amount of land directly around the parks. Two of the parks, Caroline and Sylvan, already have some open land nearby that could be utilized for a corridor. Caroline Park already borders San Timeteo Canyon through undeveloped property. If this property is left undeveloped and some additional vegetation was planted it would serve as an ideal corridor. Existing linear paths, such as railroad tracks and power line rights of ways, are open and could be easily revegetated.

However, there are some questions as to the effectiveness of corridors. Simberloff and Cox (1987) point out that it is unknown whether deep forest species will use corridors. This implies that only mobile species that can live in a more open area may benefit from the corridor. This would also apply to chaparral-requiring species. Most chaparral species rely on scrub vegetation for foraging and breeding. Many will not travel across open spaces. Scrub habitat is also necessary for shelter from adverse situations. Laurance (1991) pointed out that vulnerable animals rarely use secondary vegetation. To start building a corridor, it is often necessary to plant secondary species which grow quickly and move some birds into the area. These birds then can move between native vegetation and secondary vegetation and disperse seeds of native vegetation leading to natural regrowth. It has been observed that some chaparral birds do not require strict chaparral habitat but it seems clear that they will only move across scrub type habitat. Wrentits and Rufous-sided

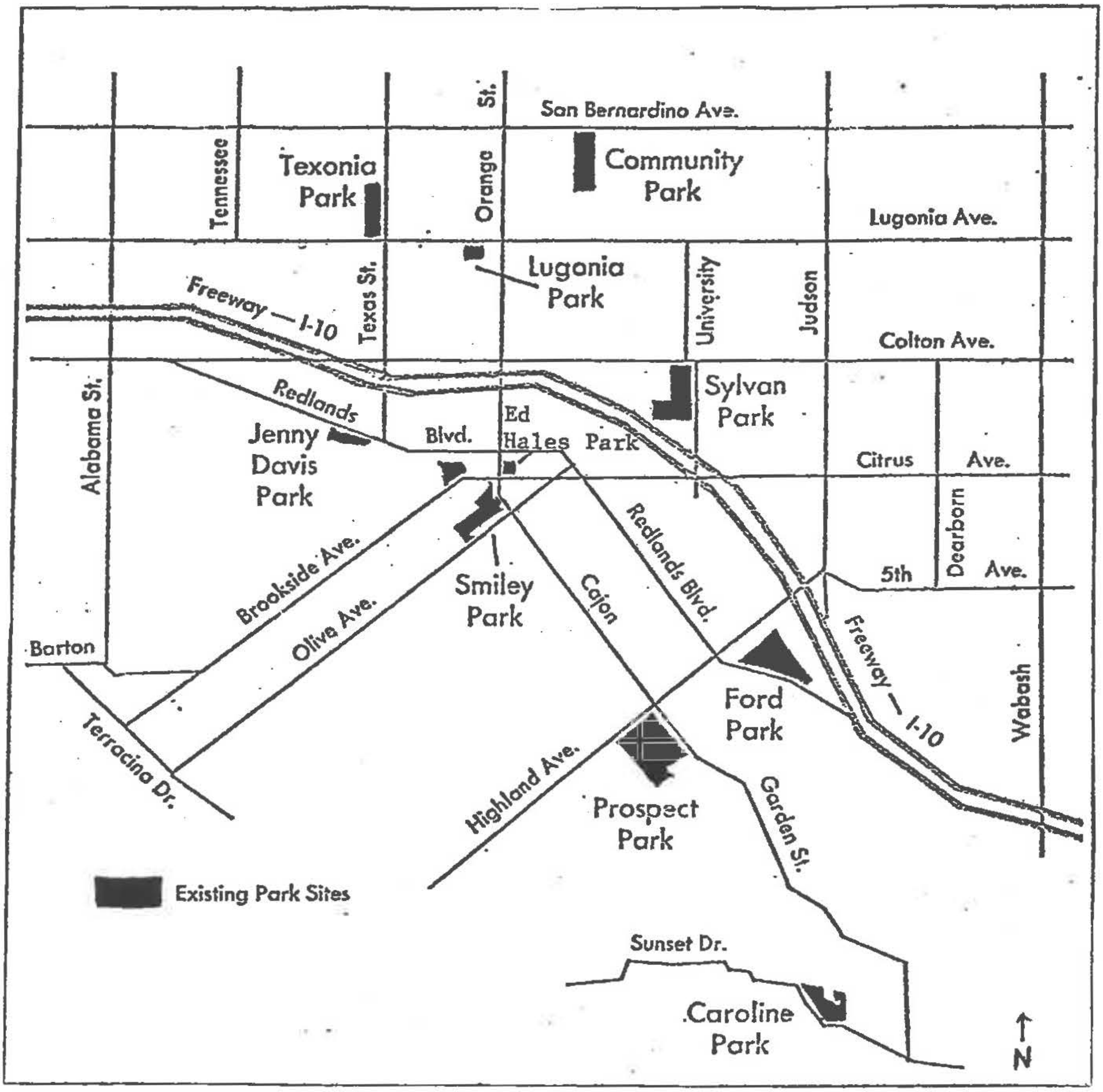
Towhees have been observed utilizing strips of vegetation as narrow as 1 meter wide (Soulé, et al., 1986). Likewise, the California Quail, California Thrasher, and Bewick's Wren have been observed using strips of land less than 10 meters wide (Soulé, et al., 1986). Thus it seems that corridors would be effective if they were developed with dense vegetation which formed a nearly continuous cover.

Are corridors worthwhile in an urban setting? In the city of Redlands it appears that a corridor that permanently linked Caroline Park to San Timeteo Canyon would allow for continued use of the park by chaparral species. As development of all open land seems inevitable in today's expanding world, the establishment of a corridor would prevent the permanent fragmentation of this park. The data has shown that fragmentation and changes in landscaping led to decreases in observations of chaparral requiring species. The data has also shown that chaparral species are alive and present in Caroline Park. Therefore it appears that fragmentation of this park would be detrimental to the chaparral species utilizing it and that the populations of these species would diminish or disappear in the future. The city has already established the purpose of this park as maintaining habitat for native plant and animal species, therefore it seems like a logical and feasible plan to protect the future of the chaparral species in the park. This would be accomplished by building a corridor between the park and San Timeteo Canyon.

For the other parks, strict chaparral requiring bird species are not as readily observed. The building of corridors between these parks and remaining chaparral vegetation would likely be reintroducing these species rather than maintaining current populations. It does not seem likely that chaparral species would move from ideal habitat to park habitat that is threatening due to human use. Also, since the main purpose of these parks is for human use, it would not seem likely that time, energy or money would be spent on building corridors.

Sylvan and Ford Parks are purposely planted with grass and trees with no trace of any chaparral habitat. Prospect Park has more variation in vegetation, with little grass and a greater variety of trees. This park also has some thickets. In all three of these parks it would be more beneficial to maintain the habitat for the continued survival of "urban" bird species rather than for chaparral species. There were 25 different species of birds observed that are not in the chaparral classification but are either residents of the city or winter migrants. Most of these birds are commonly observed and abundant. While observing, it was not uncommon to observe 10-15 White-crowned Sparrows on a single morning. All of these urban bird species seem to co-habitate well with humans that use the parks. These 25 species are all very mobile and do not depend upon specific resources or vegetation. The populations of these birds seem to be thriving if not increasing. The most beneficial plan for these parks would be to maintain the current vegetation to allow for the continued presence and diversity of non-chaparral species.

Figure 1. Location of the parks in the city of Redlands.



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Appendix 1. Common and scientific names of all species censused.

Common Name	Scientific Name
Acorn Woodpecker	*Melanerpes formicivorus*
American Crow	*Corvus brachyrhynchos*
American Robin	*Turdus migratorius*
Anna's Hummingbird	*Calypte anna*
Band-tailed Pigeon	*Columba fasciata*
Bewick's Wren	*Thryomanes bewickii*
Black Phoebe	*Sayornis nigricans*
Bushtit	*Psaltriparus minimus*
California Thrasher	*Toxostoma redivivum*
Cedar Waxwing	*Bombycilla cedrorum*
Chipping Sparrow	*Spizella passerina*
Dark Eyed Junco	*Junco hyemalis*
European Starling	*Sturnus vulgaris*
House Finch	*Carpodacus mexicanus*
House Wren	*Troglodytes aedon*
Lesser Goldfinch	*Carduelis psaltria*
Mountain Chickadee	*Parus gambeli*
Northern Flicker	*Colaptes auratus*
Northern Mockingbird	*Mimus polyglottos*
Nuttall's Woodpecker	*Picoides nuttallii*
Purple Finch	*Carpodacus purpureus*
Ruby-crowned Kinglet	*Regulus calendula*
Rufous-sided Towhee	*Pipilo erythrophthalmus*
Say's Phoebe	*Sayornis saya*
Scrub Jay	*Aphelocoma coerulescens*
Western Bluebird	*Sialia mexicana*
White-crowned Sparrow	*Zonatrichia leucophrys*
Wrentit	*Chamaea fasciata*
Yellow-rumped Warbler	*Dendroica coronata*